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Impact of cocoa (*Theobrome cacao*) leaf meal fortified with urea on haematological and serum biochemical status of West African Dwarf (WAD) goats raised under intensive system

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ABSTRACT: Haematological and serum biochemistry reflect the physiological responsiveness of animals to their internal and external environments. Cocoa leaf meal (CLM) based diet fortified with 0.5% of urea was fed to twelve West African Dwarf (WAD) goats aged between 5 and 6 months with an average live weight of 5.00±0.9 kg for 70 days. The WAD goats were randomly assigned to three treatment groups designated as G1 (0% CLM), G2 (2.5% CLM) and G3 (5% CLM). At the end of 70 days, 10 ml of blood sample was collected from each of the goats via jugular vein. About 5 ml was dispensed into an ethylene diamine tetra acetic acid (EDTA) bottle for haematological analysis, while the remaining 5 ml was dispensed into a plain bottle for serum biochemical analysis. Data obtained were analysed through a one-way analysis of variance in a completely randomized design using SPSS 2015 version 23. The results ($p<0.05$) showed that packed cell volume, haemoglobin and red blood cell were highest (32.00 %, 10.25 g/dl and 14.30 x 10^{12}/L, respectively) in G2 while MCH and MCV were highest (23.73fl and 8.13pg respectively) in G3. Neutrophil was highest (42.00%) in G1 and G3, while monocytes were highest (2.50%) in G2. Serum protein (6.90 g/dl) for G2 was significantly ($p<0.05$) higher than the mean value (6.50 g/dl) obtained in G1. Urea (43.60 and 35.80 mg/ml) and alkaline phosphate (87.50 and 81.00 U/L) in G2 and G3, respectively were significantly ($p<0.05$) lower compared to G1. The study revealed that WAD goats fed diets with 2.5% CLM could attain improved health, achieve good quality blood protein without posing any health challenge and subsequently improve the performance of the animal.

Keywords: Cocoa leaf meal, fortification, cholesterol, haemoglobin concentration, intensive, urea.

INTRODUCTION

West African Dwarf (WAD) goats are integral to the agricultural system of West Africa, serving as a valuable source of meat, milk, and economic livelihood for many rural communities (Oseni *et al*., 2017; Okoro *et al*., 2023). The WAD goats are known for their adaptability to harsh environmental conditions and low-quality forage, and they are important meat and milk-producing livestock species in many regions of West Africa (Ademosun *et al*., 2018). Goats exhibit a very high productivity potential that, if well promoted, can easily help to improve the rural economy within a very short time (Lohani and Bhandary, 2020). The productivity and overall health of these goats are inherently linked to their nutritional intake, thus making improvements in dietary strategies crucial for sustainable livestock farming in West Africa region critical (Ogunbosoye *et al*., 2022; Teixeira *et al.*, 2024). However, meeting the nutritional requirements of goats is a serious challenge due to the limited availability of high-quality forage, especially during the dry season (Aiyedun *et al*., 2019). Traditionally, the feeding practices for WAD goats have primarily centred on conventional diets, often supplemented with forages and grains. However, the

exploration of alternative feed sources has gained significance, driven by the need to enhance nutritional content and address potential deficiencies in the animals' diets (Aragao *et al*., 2022).

Cocoa (*Theobroma cacao*) is an important cash crop in many West African countries, including Nigeria and Ghana (Amujoyegbe *et al.,* 2020). Among the by-products derived from cocoa plants are the leaves. The leaves of the cocoa plant are a potential source of forage for ruminants, possessing reasonable levels of protein, fibre, and minerals (Ogunwole *et al*., 2017). Cocoa leaf meal (CLM), a by-product of cocoa production, holds promising potential as a supplementary feed, due to its availability and nutrient profile. It has been reported that cocoa biomass, like leaves, used as goats' feed can save farmers time in looking for grasses and overcome deficiencies of forage in the dry season (Aregheore, 2002). Yield research by Gunawan and Dan (2017) found out that every hectare of cocoa plantation can be optimised for raising up to 16 goats. CLM is a potential goat's feed, although not readily consumed when offered in isolation, due to its high fibre content and low protein level (Mancilla-Montelongo *et al*., 2021). To overcome this limitation, fortification with urea, a non-protein nitrogen source, has been explored as a strategy to improve the nutritional value of CLM for ruminants (Idoro *et al*., 2018). It has long been known that some of the protein in ruminant animals' diets can be substituted by urea and other non-protein nitrogen-containing substances (Iagemann, 2001). Urea also offers a strategic approach to augment the protein content of the diet, which is a critical factor influencing animal growth and overall health which plays a critical role in animal productivity. Knowing the health status of WAD goats with respect to haematological and serum biochemical status is key to optimising their performance and predicting or accessing the health status of the animals.

The haematological and serum biochemical status serves as a vital indicator of physiological well-being, reflecting the intricate interplay between nutrition, metabolism, and health status (Onasanya *et al*., 2015). Haematological parameters, including red blood cell count, white blood cell count, haemoglobin concentration, haematocrit, and blood differentials, provide valuable insights into the animals' response to dietary interventions. In the same vain serum biochemical analysis measures the protein level, albumin, globulin, cholesterol, urea, alkaline phosphate, aspartate aminotransferases, enzymes, lipids and hormones as it relates to the functioning of the animals' tissue and organs, as well as the metabolic state of the animal. It is useful for assessing the health status, clinical evaluation, survey of physiological and pathological conditions, diagnosis and prognostic evaluation of various types of diseases in animals (Etim *et al*., 2013). Normal haematological and serum parameters can be altered by an animal's exposure to abnormal conditions including environmental hazards e.g. crude oil pollution (Ngodigha, 2009), season (Abdelatif *et al*., 2009), bacterial infections (Ajuwape *et al*., 2005), or parasitic infestation (Mohammed *et al*., 2016). Blood parameters of animals could also be influenced by physiological status, breed, sex and or age (Simsek *et al*., 2015; Ayankoso *et al*., 2023).

Therefore, this study aims to assess the effect of dried cocoa leaf meal fortified with urea on the haematological and serum biochemical status of West African Dwarf goats.

MATERIALS AND METHODS

Location of the study

The study was carried out at the Goat and Sheep Unit of the Teaching and Research Farms, Faculty of Agriculture, Adekunle Ajasin University, Akungba Akoko, Ondo State. The farm is located in the rainforest vegetation zone of South-Western Nigeria between latitude 7°28'55" N and longitude 5°46'05" E. The annual rainfall ranges from 1500-2000 mm with a temperature range of 26 - 32°C (Olubanjo *et al*., 2018).

Experimental design

The twelve (12) West African Dwarf goats were allotted into three (3) treatments designated as G1, G2 and G3 containing four (4) replicates with equal number of males and females, where each animal is an experimental unit in a completely randomized design (CRD). G1 received 0 levels of cocoa leaf meal (CLM), G2 and G3 were fed with 2.5 and 5% of CLM, respectively, with the same quantity (0.5%) of urea in each diet.

Pre-experimental management and acclimatization

A total number of twelve (12) West African Dwarf (WAD) goats, aged between 5 and 6 months old with an average weight of 5.00±0.9 kg were used for the study. Before the arrival of the experimental goats, the pens were thoroughly cleaned and disinfected with Lysol® solution twice with an interval of 2 weeks to ensure the pathogenic load of the area was reduced to the minimum. The goats were procured from a popular local sheep and goat market in the Oka-Akoko area of Ondo State, which is 10.2 kilometres from the experimental site. On arrival, the animals were tagged for proper identification. They were balanced for weight and randomly allotted to various treatments. An adaptation period of four weeks was allowed for the animal during which they were given prophylactic treatments which included the intramuscular application of 20% L.A. Tetranor® (1ml/10kg body weight) and multivitamin at a dosage of 5 ml/25 kg body weight. Ivermectin® was administered subcutaneously to control parasitic worms at 0.5 ml per 25 kg body weight.

Table 1. Gross composition of experimental diets with cocoa leaf meal fortified with urea.

Ingredients	G1	G2	G3
Maize	15.00	15.00	15.00
Cocoa Leaf Meal (CLM)	0.00	2.50	5.00
Urea	0.50	0.50	0.50
Palm Kernel Cake	28.00	28.00	28.00
Rice Husk	20.00	20.00	20.00
Wheat offals	32.50	30.00	27.50
Salt	2.00	2.00	2.00
Bone meal	2.00	2.00	2.00
Total	100.00	100.00	100.00
Calculated analysis			
Metabolizable Energy	22.33	22.22	22.99
Crude Protein	12.95	13.07	13.38
Crude Fibre	13.95	14.12	14.16

Experimental diets and feeding

The ingredient compositions of the experimental diets are shown in Table 1. The diet contains dried CLM from Cocoa farms in the Akungba-Akoko area, while other ingredients were obtained from a reputable commercial feed mill in Ikare-Akoko, Ondo State. Urea was obtained from Agricultural Farm Support in Akure, Ondo State. The experimental diets were formulated using CLM as a partial substitute for wheat offal and urea as a protein boost for the diet. The formulation comprises G1 (0% CLM), G2 (2.5% CLM) and G3 (5% CLM) with the same quantity of urea (0.5%) inclusion. The animals' weekly feeding schedule was based on 4% of their body weight which was adjusted every week throughout the study. Water was supplied *ad-libitum*.

Blood collection and analysis

At the end of the study (10th week), 10 mL of blood sample was collected from each of the goats via the jugular vein. About 5 mL was dispensed into a blood sample collection bottle that contains ethylene diamine tetra acetic acid (EDTA) to prevent coagulation of the blood, to be used for haematological analysis according to the method described by Schalm *et al.* (1995) while the remaining 5 mL was dispensed into a plain blood sample collection bottle for serum biochemical analysis. The blood samples were kept in an ice pack, which was used to transport them to the laboratory for immediate analysis. Parameters considered for haematological analysis include: packed cell volume (PCV), haemoglobin (Hb), red blood cell (RBC), white blood cell (WBC), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC), neutrophil, lymphocytes, eosinophils, basinophils and monocytes count. Serum biochemical parameters investigated involved total protein, albumin, globulin, cholesterol, urea, aspartate aminotransferase and alkaline phosphate.

Feed analysis

The samples of the experimental diets were subjected to proximate analysis using AOAC (2011) methods and NR fibre fractions using the method proposed by Van Soest *et al*. (1991).

Statistical analysis

Data obtained were subjected to a one-way analysis of variance in a completely randomised design using SPSS (2015) version 23. Means among treatments showing significant differences at $p<0.05$ were separated using the Duncan multiple range test in the same package.

RESULTS

Table 2 shows the gross composition of the experimental diet used for the study. The crude protein ranged from 10.85 to 11.98% while crude fibre ranged from 11.56 to 12.82%. The fibre fractions of the experimental diets contain neutral detergent fibre with values ranging between 60.12 and 75.71%. The neutral detergent fibre of the feeds without cocoa leaf meal had the highest numerical value (75.71%) when compared with other diets' values (74.76 and 60.12 %), acid detergent fibre with values (77.22, 61.32, and 76.26%) for G1, G2 and G3, respectively. Acid detergent lignin with G3 had the highest

Table 2. Gross composition (%) of the experimental concentrate diets.

Parameters (%)	G1 (0% CLM)	G2 (2.5% CLM)	G3 (5% CLM)
Ash	6.37	6.67	6.00
Ether extract	9.57	10.14	10.48
Crude protein	10.83	11.98	10.85
Crude fibre	11.56	12.31	12.82
Nitrogen free extract	48.80	45.78	45.82
Dry matter	87.13	86.88	87.13
Neutral detergent fibre	75.71	60.12	74.76
Acid detergent fibre	77.22	61.32	76.26
Acid detergent lignin	38.20	38.25	49.46
Hemicellulose	39.02	23.07	26.80
Cellulose	39.02	23.07	26.80

Table 3. Levels of cocoa leaf meal on haematological status of WAD goats.

Parameters	G1	G2	G 3	SEM	P-value
Packed Cell Volume (%)	28.00^{b}	32.00^{a}	23.17^{b}	1.46	0.012
Haemoglobin (g/dl)	9.80^{a}	10.25^{a}	7.90^{b}	0.38	0.001
Red Blood Cell ($\times 10^{12}$/L)	12.30^{b}	14.30^{a}	9.70^{c}	0.695	0.001
White Blood Cell ($\times 10^{9}$/L)	7.30	7.50	8.00	0.32	0.712
Mean Corpuscular Volume (fl)	22.76^{ab}	22.30^{b}	23.73^{a}	0.260	0.045
Mean Corpuscular Haemoglobin (pg)	7.97^{b}	7.4^{c}	8.13^{a}	0.106	0.002
MCHC	35.00	33.50	34.33	0.285	0.073

^{a,b,c} = Means on the same row with different superscripts are significantly ($P < 0.05$) different. MCHC = Mean Corpuscular Haemoglobin Concentration, G1 (0% CLM), G2 (2.5% CLM), G3 (5% CLM).

numerical value (49.46%), followed by G2 (38.25%) while G1 had the lowest value (38.20%).

The result obtained on the effect of varied levels of dry cocoa leaf meal on the haematological status of West African Dwarf goats is presented in Table 3. Among the parameters observed; the packed cell volume (PCV), haemoglobin (Hb), red blood cell (RBC), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), neutrophil, and monocytes counts were observed, to be significantly ($p<0.05$) influenced by the diets. The PCV was highest (32.00 %) in animals in G2 while the least values (28.00 and 23.17 %) were obtained for those in G1 and G3, respectively. Haemoglobin was highest for animals in G1 (9.80 g/dl) and G2 (10.25 g/dl) while the least was obtained for those in G3 (7.90 g/dl). The highest RBC was recorded for animals in G2 while the least value was obtained for those in G3. The mean corpuscular volume was highest (23.73 fl) in animals in G3 which is comparable to the value (22.76 fl) obtained for those in G1 while the least (22.30 fl) was obtained for animals in G2. MCH was highest (8.13 pg) in animals in G3, followed by those in G1 (7.97 pg), while the least (7.40 pg) was obtained for animals in G2.

The effect of fed varied levels of dry cocoa leaf meal on the differential counts of West African Dwarf goats was presented in Table 4. The result showed that only neutrophils and monocytes were significantly ($p< 0.05$) influenced. The highest value (42.00%) for neutrophils was recorded for animals in G1 and G3 while the lowest (36.00%) was recorded for those in G2. Monocytes had the highest value (2.50%) for animals in G2 while the lowest (0.00 %) was obtained for animals placed in G1.

The effect of varied levels of CLM on the serum biochemical status of WAD goats is presented in Table 5. The results showed that all the parameters investigated were significantly ($p<0.05$) influenced by the effect of the dietary treatments except for serum total protein and aspartate aminotransferase concentration which were not significantly ($p>0.05$) influenced. The albumin concentration of animals placed in G1 had the lowest value (2.90 g/dl) while the highest values were obtained for those in G2 (3.95 g/dl) and G3 (3.50 g/dl). The globulin concentration for animals in G1 was highest (3.60g/dl) while the least (2.95 and 3.00 g/dl) were recorded for G2 and G3, respectively. The highest value (113.30 mg/ml) of cholesterol was obtained for animals in G1, followed by those in G3 (100.50 mg/ml) while the least (92.45 mg/ml) was obtained for the animals in G2. The highest (48.00 mg/ml) urea value was reported for animals placed in G1 while the least was recorded for WAD goats placed on G2 (43.60 mg/ml) and G3 (35.80 mg/ml). The alkaline phosphate followed the same trend as urea.

Table 4. Levels cocoa leaf meal on the differential counts of WAD goat.

Parameters (%)	G1	G2	G3	SEM	P-value
Neutrophils	42.00[a]	36.00[b]	42.00[a]	1.041	0.000
Lymphocytes	57.00	60.00	59.00	0.583	0.079
Eosinophils	0.00	0.50	0.00	0.117	0.125
Basinophils	000	0.50	0.00	0.118	0.125
Monocytes	1.00[b]	2.50[a]	0.00[c]	0.373	0.000

[a,b] = Means on the same row with different superscripts are significantly (P < 0.05) different. G1 (0% CLM), G2 (2.5% CLM), G3 (5% CLM).

Table 5. Levels of CLM on the serum biochemical status of WAD goat.

Parameters	G1	G2	G3	SEM	P-value
Total protein (g/dl)	6.50	6.90	6.50	0.122	0.348
Albumin (g/dl)	2.90[c]	3.95[a]	3.50[a]	0.159	0.001
Globulin (g/dl)	3.60[a]	2.95[b]	3.00[b]	0.117	0.009
Cholesterol (mg/ml)	113.30[a]	92.45[c]	100.50[b]	3.219	0.001
Urea (mg/ml)	48.00[a]	43.60[b]	35.80[b]	1.996	0.008
Aspartate aminotransferase (IU/L)	92.00	93.00	97.00	1.518	0.417
Alkaline phosphate (U/L)	97.00[a]	87.50[b]	81.00[b]	2.54	0.004

Values are means and SEM (Standard Error of Means). [a,b,C] Means on the same row with different superscripts are significantly (P < 0.05) different. G1 (0% CLM), G2 (2.5% CLM), G3 (5% CLM).

DISCUSSION

The ash content measures the amount of inorganic and non-combustible materials in the diet. The high ash content in G1 could be attributed to the absence of cocoa leaf meal (CLM) which may possibly be assumed that CLM is organic and combusts during digestion. As the ash content reduces with increased inclusion of CLM the better the feed. This corroborates the study of Omotoso *et al*. (2017) who reported that the lower the ash contents the purer the feed. The ether extract content increased with the substitution of CLM, which showed a positive reflection of energy contents in the diets. The crude protein content of the diets decreased with increasing levels of CLM. This implies that the CLM has an optimal level of inclusion after which it might not be able to meet up with the nutritional requirement of the animal, though the recorded dietary crude protein contents were adequate to support growth in ruminants (Omotoso *et al*., 2017). The increase in crude fibre with CLM might be attributed to its high lignocellulosic content (Lu *et al*., 2005) in the feed material, this is known to enhance the activities of the rumen microbes. The high dry matter content obtained could be attributed to the nature of the ingredient (dried CLM) and its maturity at the time of collection which likewise contributed to the dry matter content of the diets. The combined effects of CLM with urea in this study could synchronize the availability of some precursors for microbial protein synthesis and fibre digestion which is in line with Abdou (2010).

Haematological indices are good indicators of the physiological status of animals. They are reflections of animal responsiveness to their internal and external environments (Etim *et al*., 2013). The packed cell volume (PCV) observed in this study was within 21 to 37% recommended for healthy goats (Daramola *et al*. 2005; Plumb, 1999; Kalio *et al*., 2014). However, higher PCV obtained in animals placed in G2 might have resulted from better performance in terms of weight gain and feed conversion ratio. This indicates that the inclusion of CLM with urea supplementation could improve the health condition of West African Dwarf goats. Haemoglobin values obtained in this study were also within values (8.00-12.00 g/dl) as reported by Plumb (1999) which showed that, there was a more efficient circulatory system. It could be noted that an increase in CLM reduces the haemoglobin level of the animals which might be related to phytochemicals (tannins and alkaloides) present in CLM (Ng'ambi *et al*., 2016; Gunawan and Dan, 2017).

The red blood cells obtained for WAD goats fed with CLM fortified with urea in this study fell within the normal values ($8 – 18 \times 10^{12}$/L) recommended by Plumb (1999) for healthy goats. This indicated the quality of the feed and its capability to meet the nutrient requirements of the animal. White blood cells in this study were lower than the values ($9.9–18.7 \times 10^9$) reported by Taiwo and Ogunsanmi (2003) and Ibhaze (2015) and higher than the values ($6.67–7.73 \times 10^9 m^3$) opined by Oloche *et al*. (2014). This showed that the animals were not stressed, and neither had any infection which would have raised white blood cell value as a measure to generate immune system value in animals. Mean corpuscular volume and mean corpuscular haemoglobin in animals fed with CLM indicated that, it is

capable of improving blood formation. Mean Corpuscular Volume (MCV) and Mean Corpuscular Haemoglobin (MCH) values obtained were closely related to the values (21.83 and 22.18 fl) and (7.58–8.50 pg), reported by Mitruka and Rawnsley (1977) and Ogunbosoye *et al*. (2018), respectively. It should be noted that extremely low MCH is an indicator of macrocytic (regenerative) anaemia.

When microorganisms, such as bacteria or viruses, enter the body, neutrophils are one of the first immune cells to respond (Daramola *et al*., 2005). They travel to the site of infection, where they destroy the microorganisms by ingesting them and releasing enzymes that kill them. Least neutrophils level obtained with G2 showed that it was not necessary to be stimulated since there was no infection, and the neutrophil values obtained were within the normal range (17-52%) recommended by Daramola *et al*. (2005) for healthy goats. This indicates that there was no occurrence of neutrophilia which could occur when the animal is under trauma or neutropenia which could occur with severe infections. The introduction of CLM in G2 reduced the percentage of neutrophils in the body of the animal. However, the value went up again when the quantity of CLM was increased. This could be that, CLM has a level of stress it imposes on the immune status of the animal when given in excess. This is in line with the report of Omotoso *et al.* (2017) where they reported reduced immune response in goats fed on grass and cocoa husk. The values of monocytes in this study were significantly ($p<0.05$) different between dietary treatments. Monocytes indicate the presence of foreign bodies in the blood of the animals, however, the lowest value obtained from animals in G3 (highest CLM) showed that an increased level of CLM reduces the expression of foreign bodies in the animal (Anya *et al*., 2018).

Blood serum parameters are reliable indicators of health status, reflecting the physiological, nutritional, or even pathological changes that occur in the organism (Simaraks *et al*., 2004; Koronowicz *et al*., 2016). Albumin indicates the degree of haemoglobin concentration as well as the level of protein utilisation from the feed (Pavlík *et al*., 2007; Greene *et al*., 2013). The highest value of albumin obtained in group G2 fed with 2.5% CLM showed that the major proportion of protein obtained from the diet is directed towards the formation of albumin which is important in performing physiological roles, such as proffering curative role during injury, and helps to speed up the blood clot, which lessens blood loss. The values obtained in this study fell within the normal range of 2.4–4.4 g/dl as also reported for healthy goats by Tambuwal *et al*. (2002), but lower than the values reported by Ayankoso *et al*. (2023) who drenched goats with apple cider vinegar and got slightly higher values (2.63–3.25 g/dl) reported by Ogunbosoye *et al*. (2018) for a clinically healthy goat. The variation could be due to differences in the age of animals and different test ingredients used. The higher albumin obtained could also result from elevated levels of crude protein in G2, which may have caused increased albumin in the group fed with the diet.

This study showed that globulin levels of animals in diets 2 and 3 fed with varied proportions of CLM were within the normal range (2.7–4.43 g/dl) as reported by Yakubu *et al*. (1986) but lower than the range (3.40 g/dl to 5.0 g/dl) mentioned by Kaneko (1989) for healthy goats. These lower values might be due to the mobilization of proteins from the diets in the formation of albumin possibly to meet up with specific body requirements in the animal body. Cholesterol functions in tandem as a building block of cells and a precursor of steroid hormones (Pavlík *et al*., 2007). Cholesterol values in this study are within the normal physiological range of 55-200 mg/dl reported by Pampori (2003). In line with the studies conducted by Esonu *et al*. (2001), the proportion of protein consumed and the ability to better utilize it might have influenced the least cholesterol value obtained in G2. Since the primary structural element of animal cell membranes is cholesterol, and the biosynthesis of bile acid, vitamin D, and steroid hormones is dependent on cholesterol. Also, it is the primary sterol that all animals synthesize which plays a crucial role in controlling the fluidity of animal membranes. Therefore, values obtained in this study could be of great benefit to the animals in maintaining body fluid.

The urea level recorded in this study was higher than the value reported by Tambuwal *et al*. (2002) which could have resulted from urea used in this study to increase CLM consumption and utilization, this showed that urea-fortified multi-nutrient feeds, either with or without CLM might have increased catabolic response in animals. Although, higher urea obtained could serve as a source of nitrogen for protein biosynthesis but could be likened to excessive tissue protein catabolism which is associated with protein deficiency resulting from elevated serum urea level (Oduye *et al*., 1976). So, CLM with urea incorporation into the diet could ameliorate tissue protein catabolism.

It is a common practice to use the activities of alkaline phosphate as a biochemical marker of liver function. The lower values of alkaline phosphate obtained in the group fed varied levels of cocoa leaf meal indicated that it did not have any negative effect on liver function. This also suggested the positive effect of the inclusion of CLM fortified with urea in the diets of West African Dwarf goats. This agrees with Ahmad *et al*. (2012) who reported that increased levels of alkaline phosphate in the blood stream could cause structural and functional changes in the liver. Alkaline phosphate values in this study are within the values (42-775 U/L) reported by Blood *et al*. (2007) for normal physiological goats. This suggests that there was no harm done to the liver, heart muscle, muscle cells, or liver functions and might have improved the formation of bones of the experimental goats.

Conclusion

From the findings of this study, it could be concluded that

CLM fortified with urea in the diet of goats at a 2.5% inclusion rate did not have any deleterious effect on the health status of the goats but rather, improved their haematology (packed cell volume, haemoglobin and red blood cell) and serum biochemical status (albumin and cholesterol) for optimal performance and productivity.

Recommendations

1. It is hereby recommended that CLM fortified with urea in the diet of goats at a 2.5% inclusion rate should be maintained.
2. Further studies should be carried out in related areas using CLM.

CONFLICT OF INTEREST

The authors declare that they have no conflict interest.

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